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Workability and mechanical properties of concrete with volcanic powder

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Abstract. In order to keep the balance between construction industry development and environment protection, achieve the sustainable development between economy and the environment. As a part of sustainable development policy, this study aims to replace fly ash with volcanic powder for making concrete. By making volcanic powder mortar to find out the range of optimum mix amount. And study the suitability of replacing fly ash by volcanic powder in producing concrete and find out the influencing rule of water cement ratio, volcanic powder content and sand ratio.

Introduction

The growing needs of material resources and the requirements of environmental protection impels us to use waste material. China has rich volcanic resources and which had been applied extensively in a lot of professions[1,2]. Processing volcanic rock produce a large number of volcanic powder in stone factory, abandoned powder pollute the environment. And with the thermal power station decreases, the yield of fly ash will reduce. In addition, making concrete with volcanic powder, SiO_2 and Al_2O_3 reacts with $Ca(OH)_2$ to form Calcium silicate hydrate (CSH), it can Improve the quality of concrete[3].

As a part of sustainable development policy, in order to solve the shortage of fly ash and Protect the environment and improve mechanical resistances and the durability of concrete, this study use volcanic powders as supplementary cementitious materials for concrete.

Raw Material

The raw materials of concrete are cement, additive, mineral admixture, fine aggregate and coarse aggregate. These materials are mixed with water, molded and turned to be high strength mixture. The type of Portland cement is P.O 42.5 and which was supplied by China national building material group. In this study, the secondary FA and S95 grade ground slag was used to make cement, which are provided by respectively Shenzhen Mawan Power plant and Shenzhen Xiaoyetian Cement plant. Water reducing agent: polycarboxylate superplasticizer, from Shenzhen Gangwan concrete batching plant, and water-reducing rate is 25%. volcanic rock of the Guangdong was ground at 25min, specific surface area is 484.57m2/kg. Fine aggregate: the fineness modulus of river sand was 2.6; Coarse aggregate: continuous gradation gravel, the particle diameters of gravel was 5-25mm.

Laser Particle Size Analysis. Particle size distribution is an important physical indexes of volcanic powder. The particle size distribution of raw materials have a great influence on the performance of concrete, the volcanic powder fineness were detected by laser particle size analyzer. The results of the particle size distribution are shown in Fig 1. some difficult ground minerals show independent distribution peaks in the coarse particles.

Particle morphology analysis. The particle morphology of mineral admixture has a great influence on the performance of concrete. And the picture of raw materials was obtained via polarizing microscope in Fig 2.

Maintaining the Integrity of the Specifications. The chemical composition of the volcanic indicates a salic mineral. volcanic powder's chemical composition is mainly SiO_2 and $A1_2O_3$, The content of

two minerals is above 69% , and chemical composition is great. Volcanic powder would react with calcium hydroxide to form more calcium silicate hydrate. Mixing volcanic powder into concrete would exhibit considerable enhancement in durability properties.

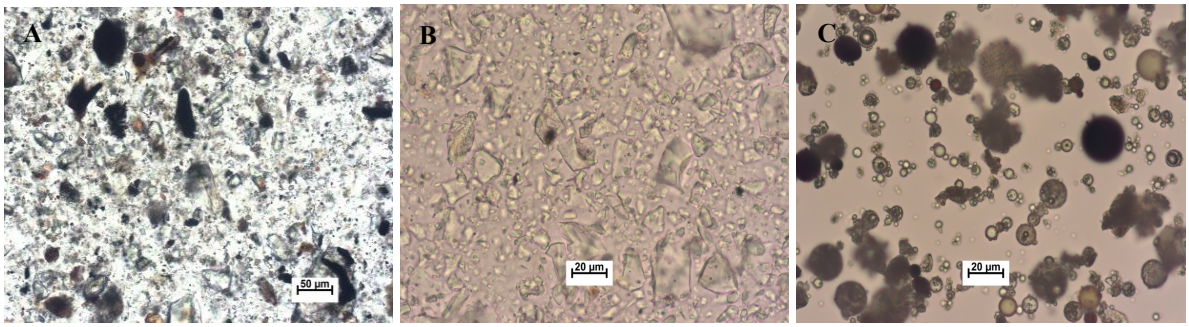

Fig. 1, Polarizing microscope image of volcanic powder(A), slag powder(B), fly ash(C).

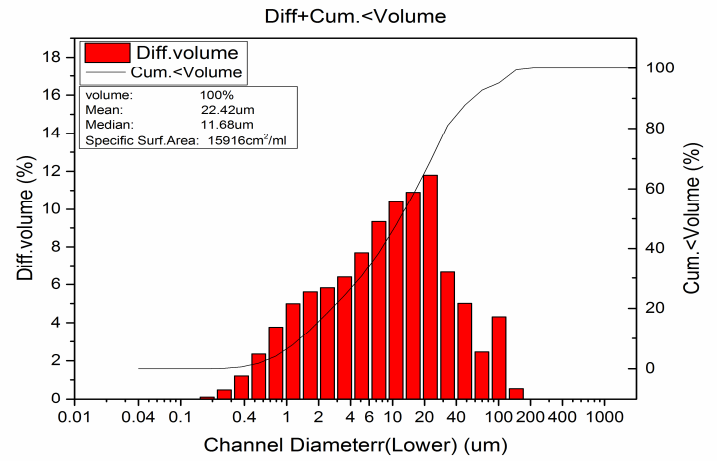

Fig. 2, Laser particle size distribution of grinding 25min volcanic powder.

Table 1,Chemical composition of volcanic powder [wt%].

	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	Na_2O	K_2O	SO_3	Loss
volcanic powder	50.43	16.36	8.95	4.44	9.95	4.58	1.72	--	--

volcanic powder mortar

As shown in Table 2, find out the range of optimum mix amount through making volcanic powder mortar .

Compressive strength can not indicate the strength contribution of volcanic powder to concrete. Use this formula to find out the range of optimum mix amount [4].

$$R_c = R_a / q_0. \quad (1)$$

R_c---Compressive strength of concrete with 100% cement content

q_0--- Percentage of cement in concrete

$$R_j = R_c / 100. \quad (2)$$

$$A = (R_c - R_j) / R_c * 100\% / q. \quad (3)$$

R_a---- Compressive Strength of concrete containing Volcanic powder

q---Percentage of volcanic powder in concrete

As The Table 3 shown, the amount of volcanic powder should be less than 20% in concrete.

Table 2, Test results of volcanic mortar.

Number	Cement (Wt%/g)	Volcanic powder(Wt%/g)	Standard Sands(g)	water cement ratio
X0	100/450	0/0	1350	0.5
X1	90/405	10/45	1350	0.5
X2	80/360	20/90	1350	0.5
X3	70/315	30/135	1350	0.5
X4	60/270	40/180	1350	0.5

Table 3, strength contribution of volcanic powder.

number	Volcanic powder /Wt%	Compressive strength/Mpa		Rj		Rc		A	
		7d	28d	7d	28d	7d	28d	7d	28d
X0	0	63.83	79.48	0.64	0.79	-	-	0	0
X1	10	66.53	76.23	-	-	0.74	0.85	1.35	0.71
X2	20	53.11	64.10	-	-	0.66	0.80	0.15	0.063
X3	30	44.05	54.55	-	-	0.63	0.78	-0.005	-0.043
X4	40	34.85	45.76	-	-	0.58	0.76	-0.26	-0.099
X5	50	26.44	34.7	-	-	0.53	0.69	-0.42	-0.290
X6	60	19.84	20.37	-	-	0.50	0.51	-0.47	-0.4

Results and discussion

Concrete Grade of Strength design is C40. Using volcanic powder, Water reducing agent and Sand ratio as variable,water cement ratio is 0.39, content of volcanic powder and slag is 45%. As Figure 6 shown, the amount of volcanic powder was less than 20% . The study used 55 wt % of cement, 0.39 of water cement ratio. The 28d test results are shown in Table 4.

As the Fig 3 shown, effection of various factors on compressive Strength : volcanic powder＞ Water reducing agent ＞Sand ratio. With the increase of volcanic powder，compressive Strength decreases. The activity of volcanic powder is lower than slag and which will reduce ompressive Strength. With the increase of sand ratio, compressive Strength decreases initially and increases afterwards. The sand ratio of 45wt% is most suitable for the particle size distribution of the concrete. The effect of Water reducing agent on compressive strength is similar to Sand ratio. Too low water cement ratio will increase hydration heat and make the workability worse; Too high water cement ratio will reduce the strength of concrete. The water reducing agent can reduce water consumption, increase strength and save cement dosage.

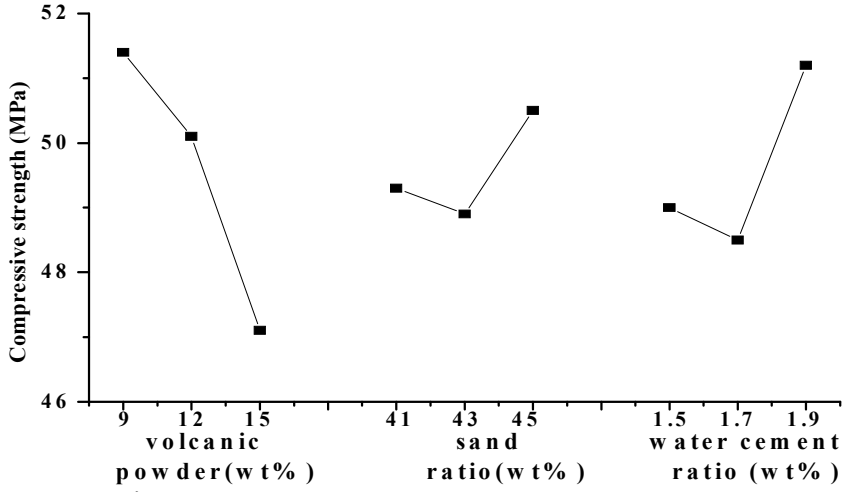

Fig. 3, Effect of various factors oncompressive Strength.

Table 4, The test result.

Number	Water cement ratio	Water reducing agent (Wt%)	Cement (Kg/m3 /Wt%)	Volcanic powder (Kg/m3 /Wt%)	Slag (Kg/m3 /Wt%)	Sand (Kg/m3 /Wt%)	Compressive Strength (MPa)
R1	0.39	1.9	210/55	57/15	114/30	819/45	52.3
R2	0.39	1.7	210/55	57/15	114/30	782/43	49.4
R3	0.39	1.5	210/55	57/15	114/30	746/41	44.7
R4	0.39	1.7	210/55	46/12	126/33	819/45	48.4
R5	0.39	1.5	210/55	46/12	126/33	782/43	51.5
R6	0.39	1.9	210/55	46/12	126/33	746/41	50.5
R7	0.39	1.5	210/55	34/9	137/36	819/45	50.8
R8	0.39	1.9	210/55	34/9	137/36	782/43	50.9
R9	0.39	1.7	210/55	34/9	137/36	746/41	52.6

Conclusions

Based on the experimental data, replacement of fly ash with volcanic powder is feasible.The content of volcanic powder in concrete should be less than 15%. The influence of various factors are considerated comprehensivly, volcanic powder content have great influence on compressive strength .And Water reducing agent and Sand ratio have a certain degree of influence.

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